# Particle Production in Proton-Proton and Deuteron-Gold Collisions at RHIC

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**Abstract**

We try to understand recent data on proton-proton and deuteron-gold collisions at RHIC, employing a parton model approach called EPOS.

## 1 Introduction

EPOS is a new energy conserving multiple scattering approach based on partons and Pomerons (parton ladders), with special emphasis on high parton densities. The latter aspect, particularly important in proton-nucleus or nucleus-nucleus collisions, is taken care of via an effective treatment of Pomeron-Pomeron interactions. Soft and hard interactions are treated in a consistent way. EPOS is the successor of the NEXUS model.

## 2 High parton densities

Let us first consider parton-parton scattering. A parton from the projectile, after emitting several (initial state) partons, interacts with a corresponding parton from the target, see figure 1A (left). To simplify graphical representations in the following, we use a symbolic parton ladder , as shown in figure 1A (right), representing both soft and hard interactions.

Having several target partons available, the projectile parton may interact in this way with any of the target partons, as shown in fig. 1B, which will simply change the cross section by some factor.

The situation will, however, be more complicated in case of high parton densities. Here, a parton from a ladder may rescatter with another parton from the projectile or target, providing an additional ladder (fig. 2A).

[1]Invited talk, given at SQM2004, Cape Town, South Africa, 15-20 September, 2004

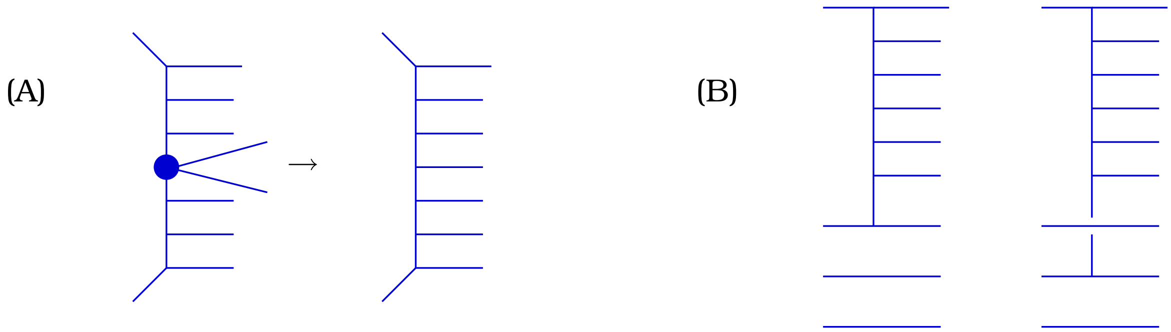


Figure **1**: (A) Parton-parton scattering. (B) Scattering with many partons.

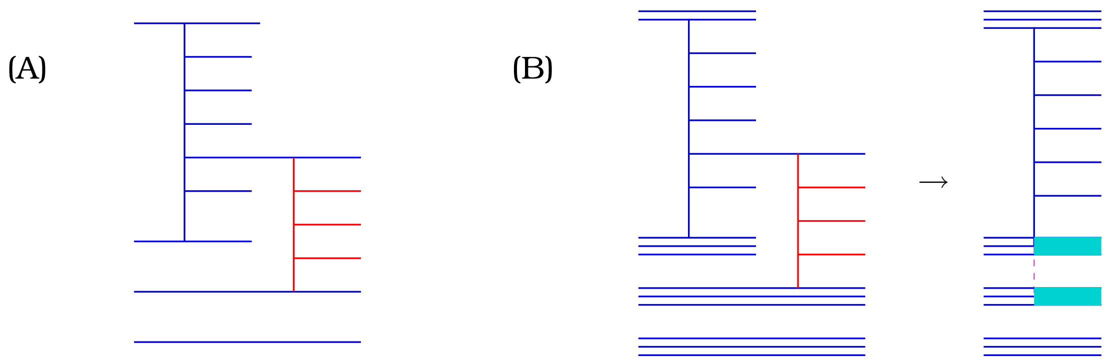


Figure **2**: (A) Multiple ladders. (B) Effective treatment of multiple ladder contributions.

We try to model such high density effects

- ☐ in a simple and transparent way,
- ☐ using just simple ladders between projectile and target (Pomerons),
- ☐ putting all complications into "projectile / target excitations", to be treated in an effective way,

as shown in fig.2B. Bifurcation of parton ladders will not be treated explicitly, they are absorbed into target and projectile excitations, visualized as fat lines in the figure. The excitations may represent one, two, or even more ladders, depending on the parton densities.

**How to realize these ideas?**

For a given target nucleon $j_0$, we define the number $Z_{\mathrm{T}}(j_0)$ of additional partons on the target side being available for multiple interactions, as seen by the

projectile nucleons interacting with $j_0$ :

$$Z_{\mathrm{T}}(j_0) = \sum_{\substack{\text{proj.nucleons}\, i \\ \text{interacting} \\ \text{with}\, j_0}} \max\Big(0, \sum_{\substack{\text{target} \\ \text{nucleons}\, j}} z(b_{ij}) \; - 1\Big)$$

with

$$z(b) = \frac{z_0(E)}{\sqrt{b_{\mathrm{cut}}^2 + b^2}} \Theta\Big(\sqrt{\frac{\sigma_{\mathrm{inel}}}{\pi}} - b\Big).$$

A corresponding definition holds for $Z_P$. For pA: $Z_{\mathrm{P}} \approx 0$, $Z_{\mathrm{T}} \propto N_{\text{target participants}}$.

**How to realize projectile / target excitations ?** (accounting for multiple, interacting ladders)

We suppose an excitation mass distributed according to $1/M^{2(1-\mu)}$. Low masses correspond to hadrons or resonances, high mass excitations are considered to be strings.

The string parameters $\langle\, p_t^{\text{string break}} \,\rangle$and $p_{\text{strange}}$, as well as $\mu$ and $\langle\, p_t^{\text{string end}} \,\rangle$ of the strings connected to an excited target/projectile, depend on $Z$ as $f = f_0\, \min(Z_{\max}, 1 + aZ)$.

To provide some numbers: $Z_{\mathrm{T}}(\text{centr dAu}) \approx 3 - 4$, $Z_{\mathrm{T}}(\text{periph dAu}) \approx 0$, $Z_{\max} \approx 4$, $a \approx 1$.

The formalism is based on cut diagram techniques, strict energy conservation, and Markov chains for the numerics [1].

# 3 Some results

Very detailed tests show that the model works very well for pp scattering. As an example, we show in fig. 3 mean transverse momenta for different hadron species.

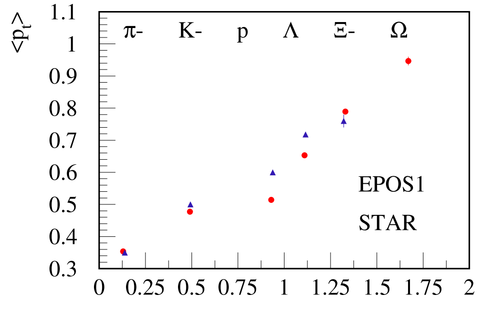


Figure **3**: Mean transverse momenta in pp collisions; data (triangles) from ref. [2].

Concerning the nuclear modification factor $R = AA/pp/N_{\rm coll}$ as a function of $p_t$, in d+Au collisions, we observe an increase beyond one, as observed in the data, see fig. 4, due to the fact that $Z_T$ becomes quite big (up to 3-4).

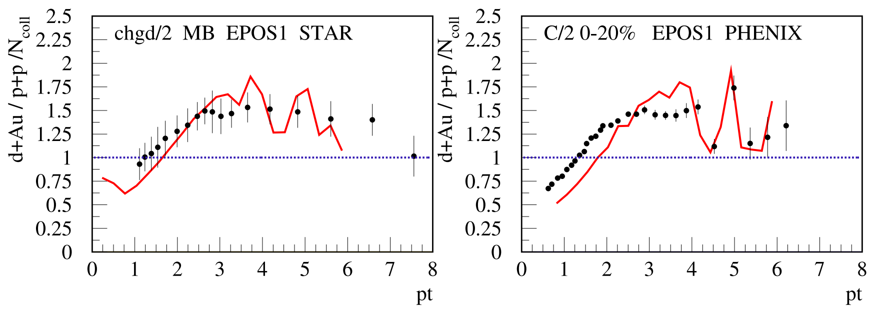


Figure **4**: The nuclear modification factor; data (points) from ref. [2, 3].

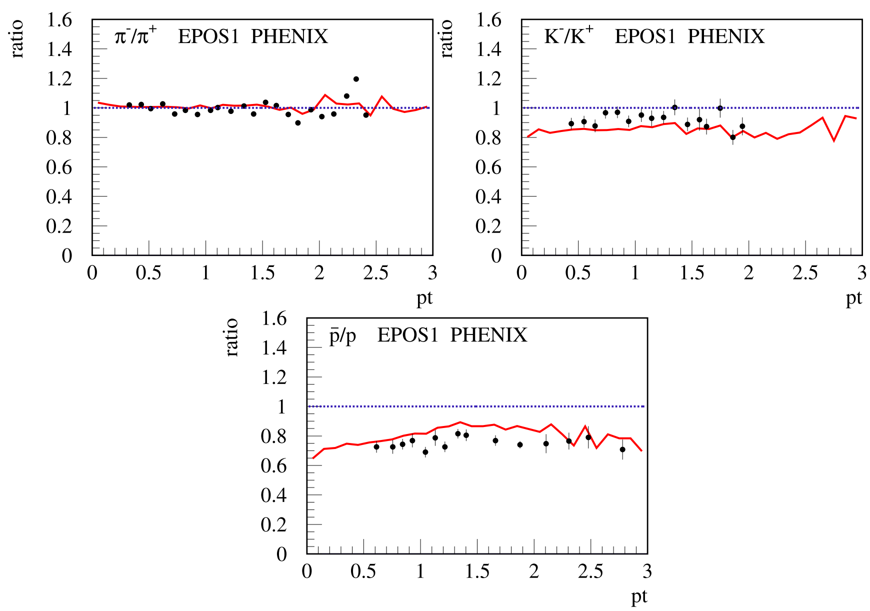


Figure **5**: Transverse momentum dependence of hadron ratios; data from ref. [3].

In fig. 5 finally, we show the transverse momentum dependence of hadron ratios. The pt dependence in mainly determined by the mass of the particle, so ratios of particles of equal mass are essentially constant.

# References

[1] H.J. Drescher, M. Hladik, S. Ostapchenko, T. Pierog, K. Werner, Phys. Rept. 350 (2001) 93

[2] STAR, Phys. Rev. Lett. 91 (2003) 72304, and contributions to this conference

[3] PHENIX collaboration, Phys. Rev. Lett. 91:072303 (2003), and F. Matathias, presentation at Quark Matter 2004.